

CIGRE 481

Virtualization of the Experiential Learning Platform for Critical Energy Infrastructure using Digital Twin Technology and Cloud-based Applications

Authors:

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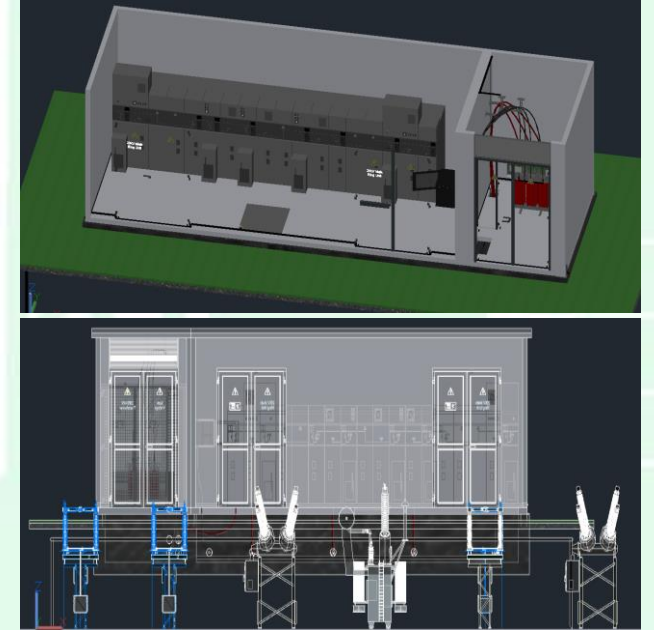
(November 2022)

Introduction:

- Advent and Expansion of Industry 4.0/5.0 critical infrastructure technologies and applications
- Post-pandemic working and training environment
- Challenge: effective hands-on training remotely
- Necessity: design and development of Virtualized Experiential Learning Platforms

Virtualized Platform Features:

- Specifically designed for Vocational Training
- Cover most recent technologies and solutions
- Reliable remote access and connections
- Flexible for different modules and practices
- Cybersecure against cyber threats



BCIT's Critical Infrastructure Cybersecurity Lab (CICL):

A real-time R&D platform, enabling researchers/educators to conduct research & training programs in:

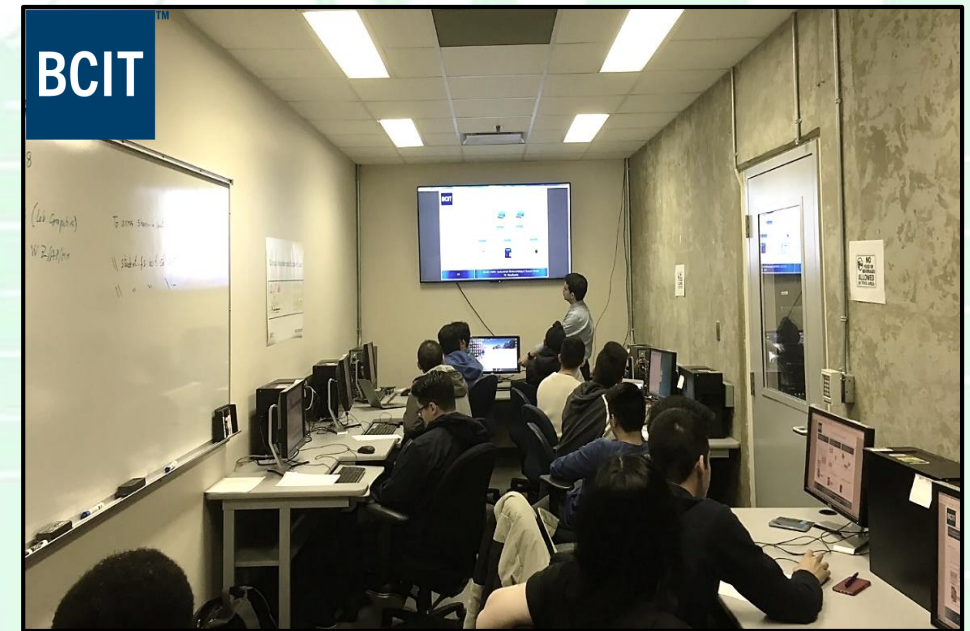
- Power Systems
- Modern Digital Substations
- Substation Automation Systems
- Industrial Control Systems
- Smart Grids
- Critical Infrastructure Cybersecurity



BCIT's Critical Infrastructure Cybersecurity Lab:

Provide Training Programs, Workshops, and Courses:

- Students from different programs/courses
 - Since 2017: more than 250 Students
- Utility experts/personnel
- Other interested parties

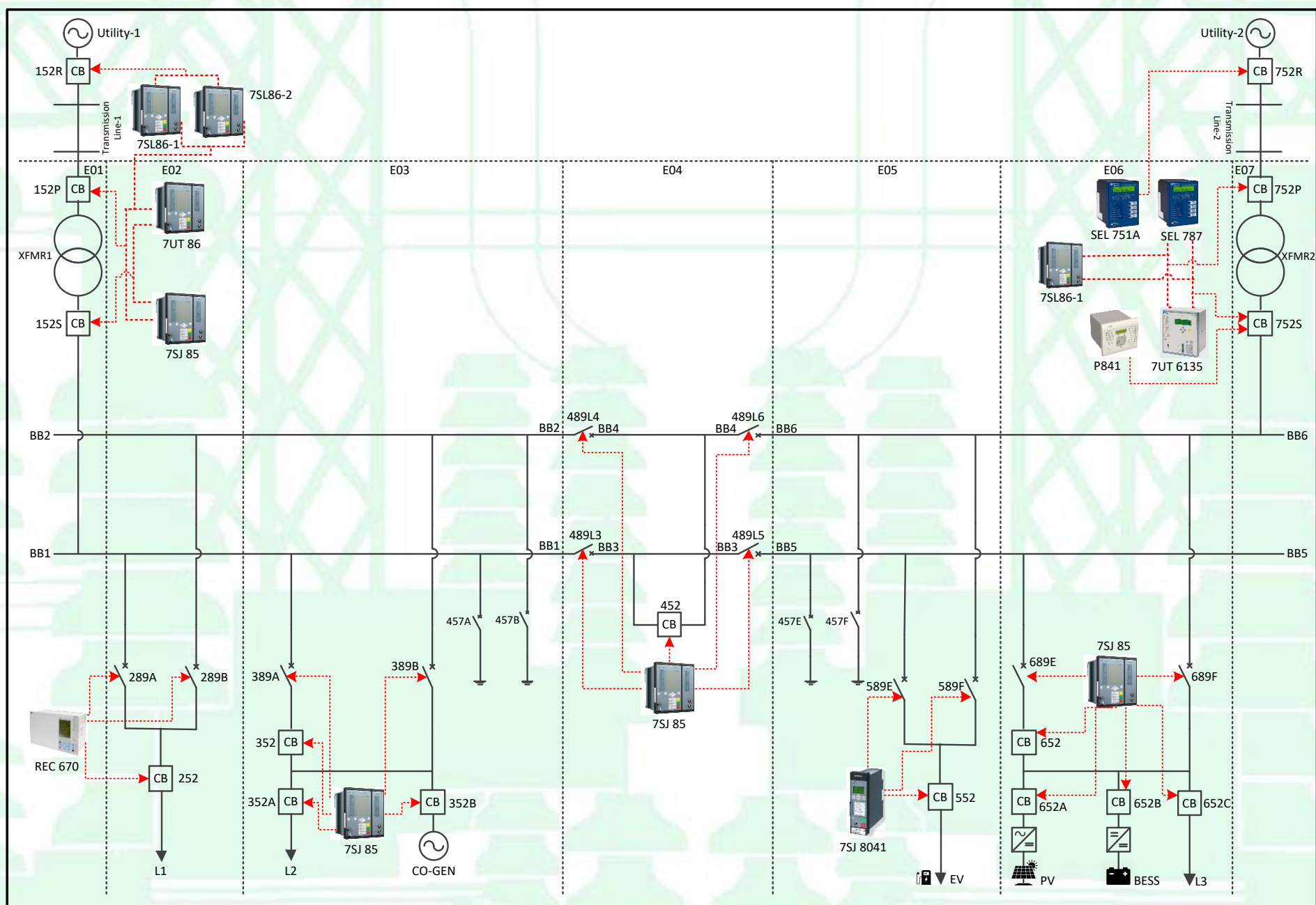


Future Skills Centre Program Fund: \$1.569M

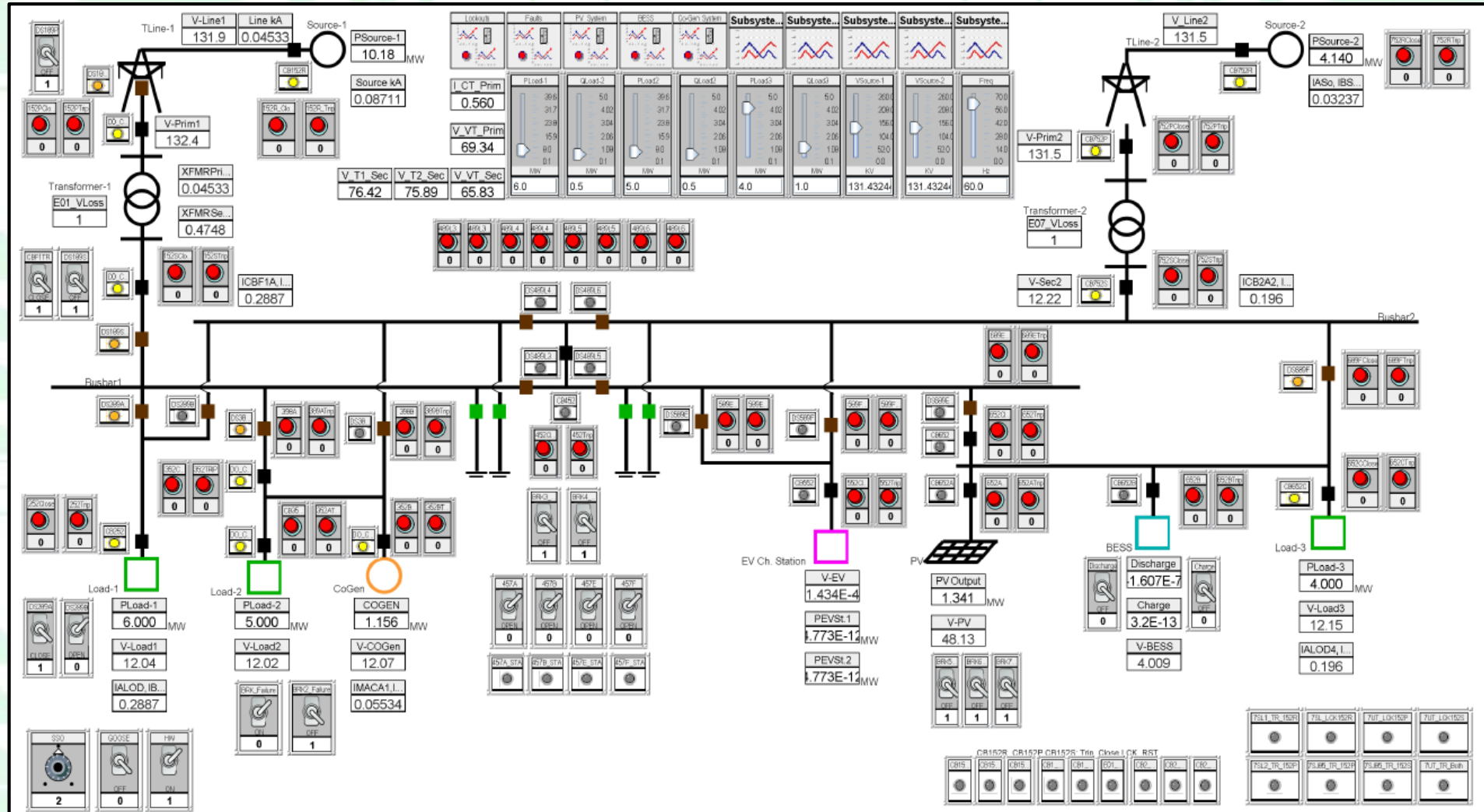
CICL Physical Assets and Components:

Real-time Digital Simulators and IEDs form different vendors

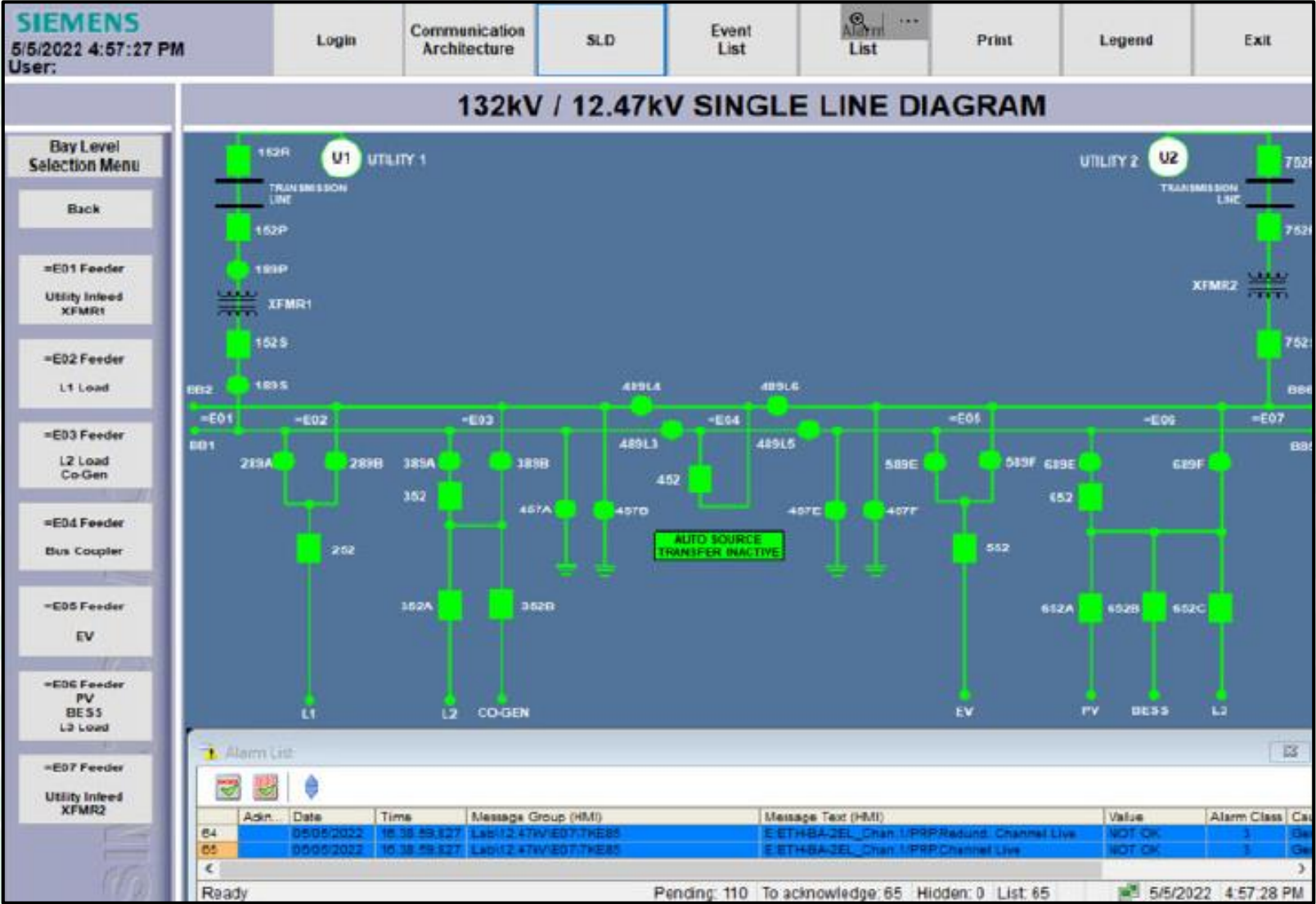




CICL Real-time Monitoring Platforms:



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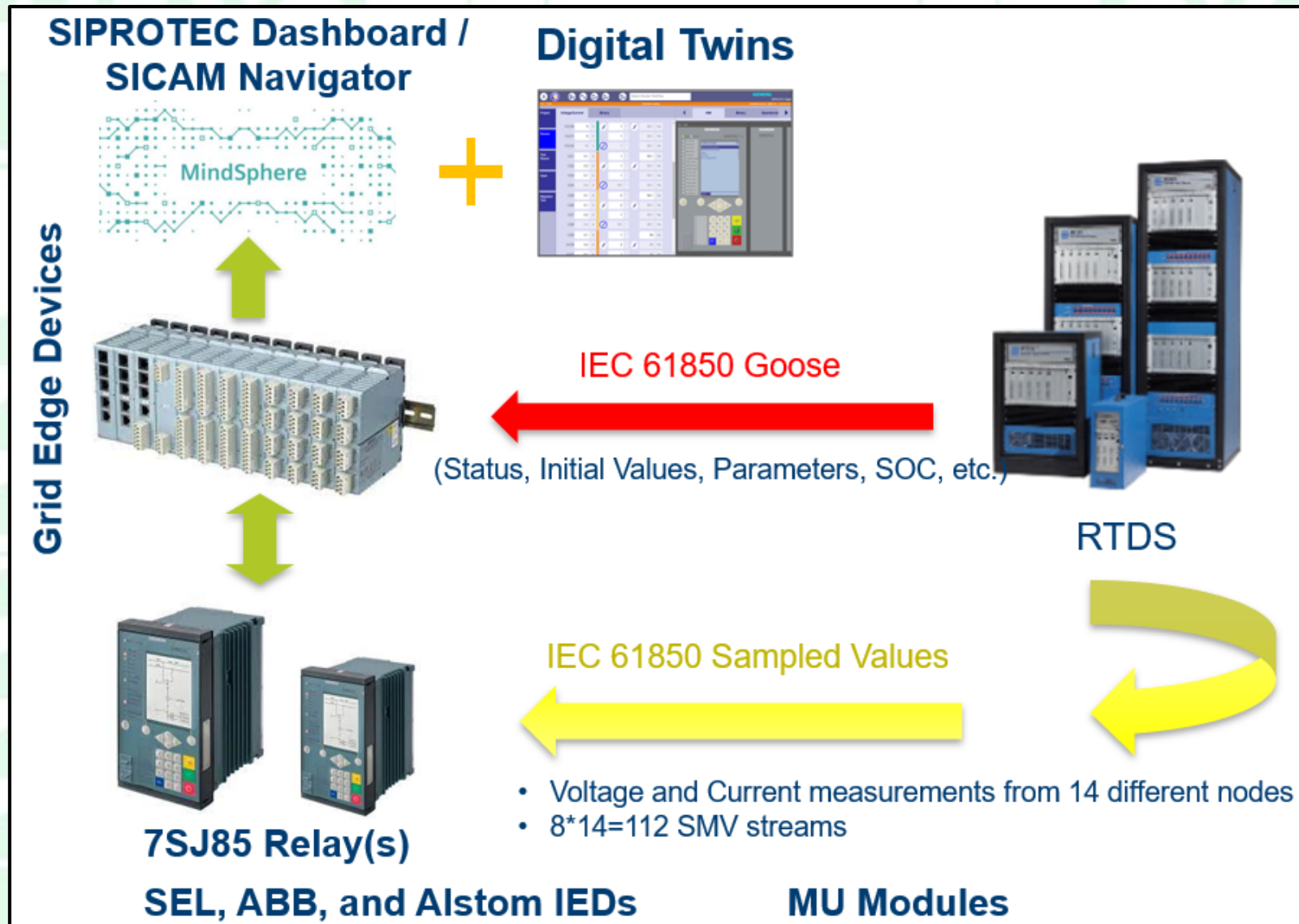
Cluster of Activities for Virtualization:

0. Learn the needs and plan for the process
1. Design required architectures: communication topology, etc.
2. Model critical energy infrastructure using a real-time HIL simulator
3. Virtualization through virtualization platforms (not only visualization)
4. Replication of data, control and/or command signals in the cloud

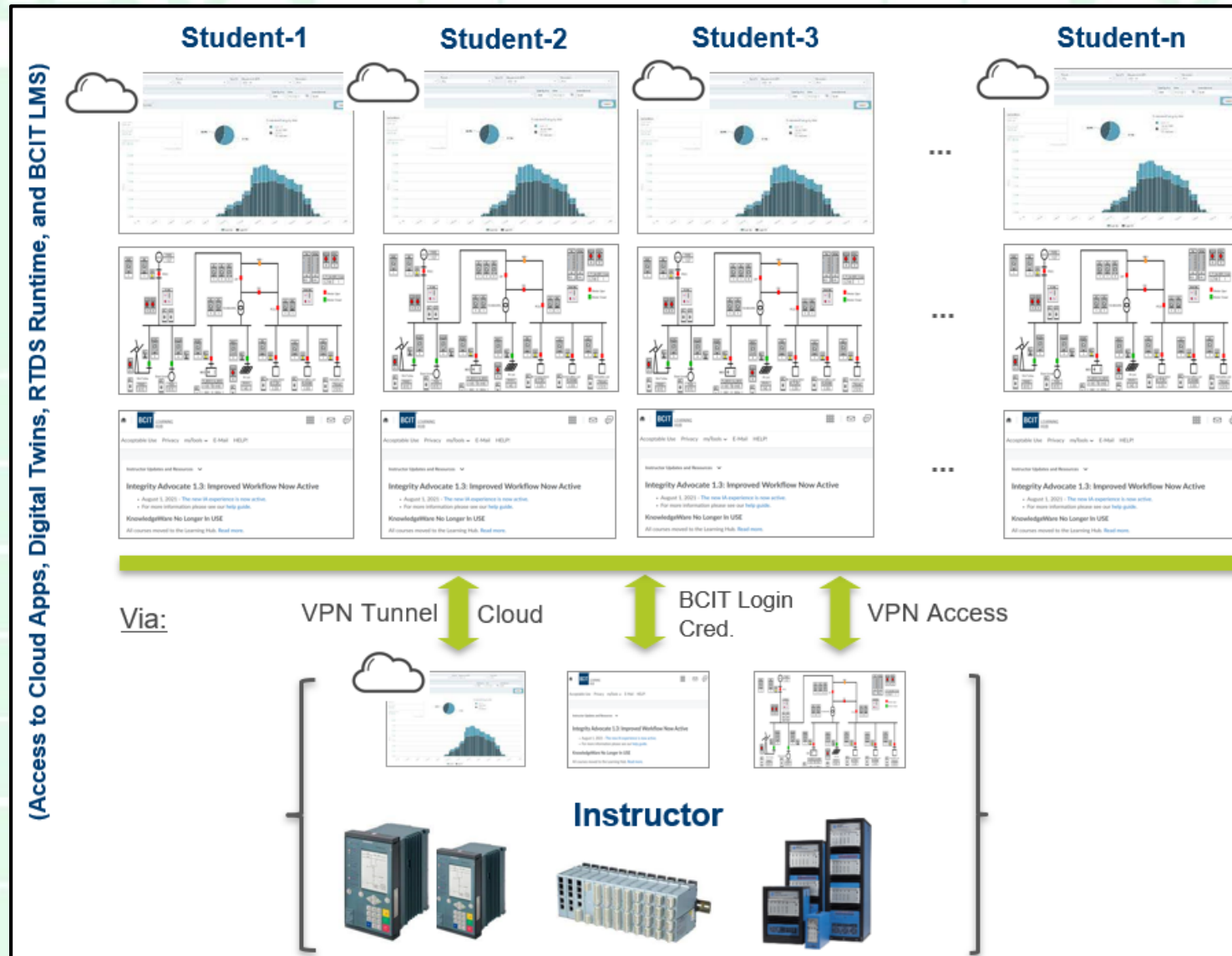
Cluster of Activities for Virtualization (cont.):

5. Utilize cloud-based applications
6. Configure online systems and applications such as digital twins
7. Establish cybersecure remote access connections
8. Final integration considering future expansion
9. Validation and Verification tests
10. Run Pilot Sessions

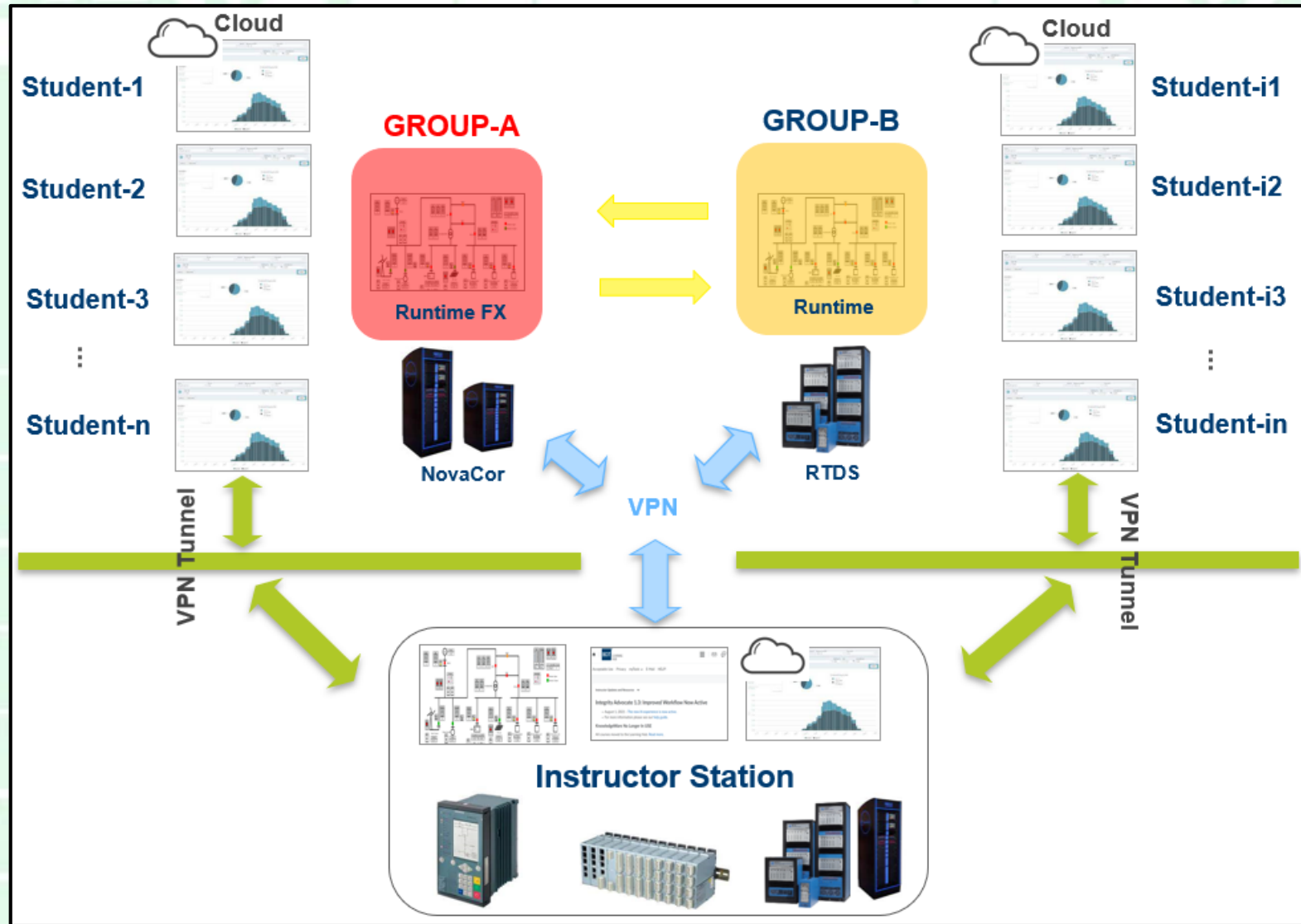
Virtualized Experiential Learning Platform Architecture:



Remote Access:



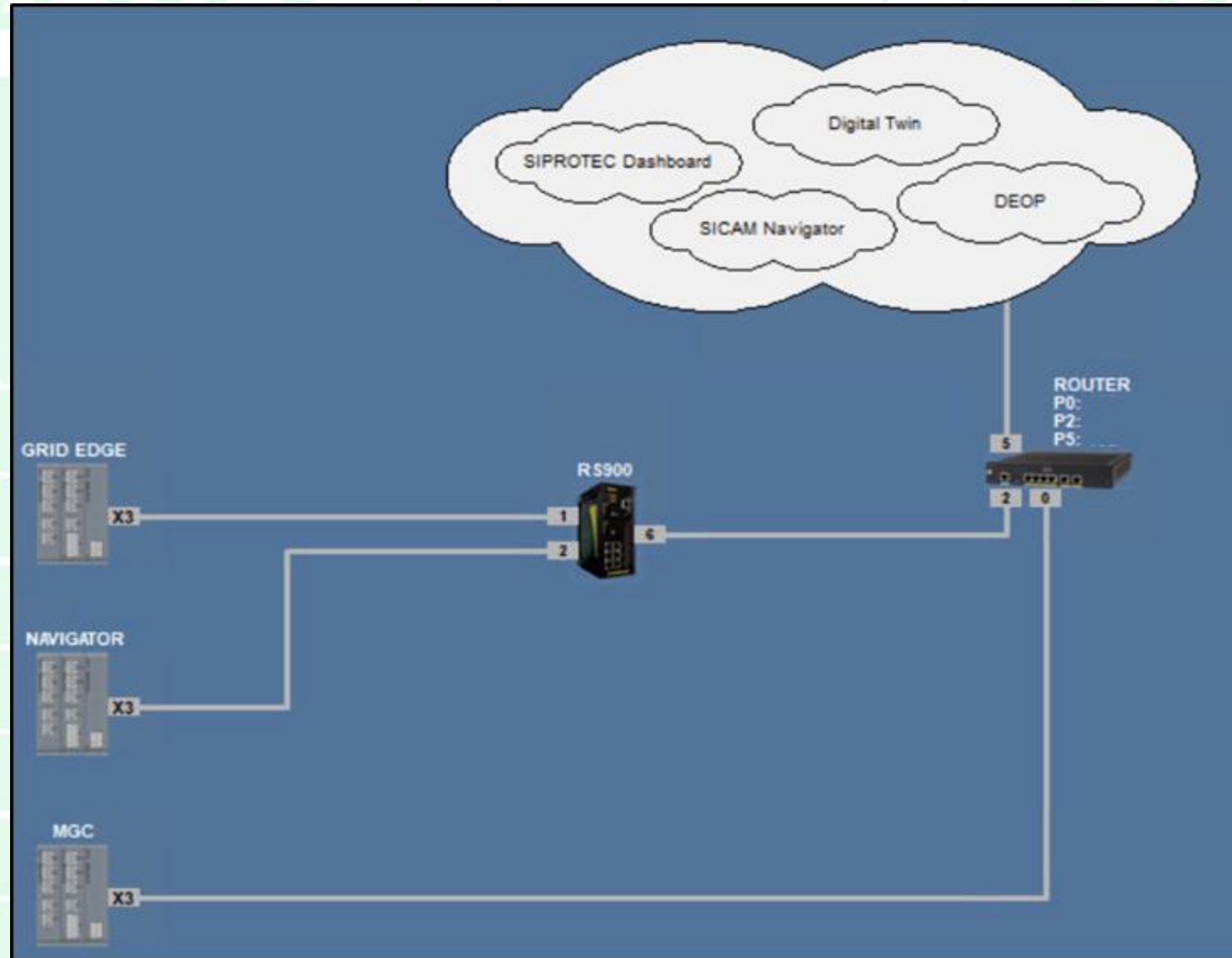
Remote Access for Group-based Modules:



Communication Architecture:

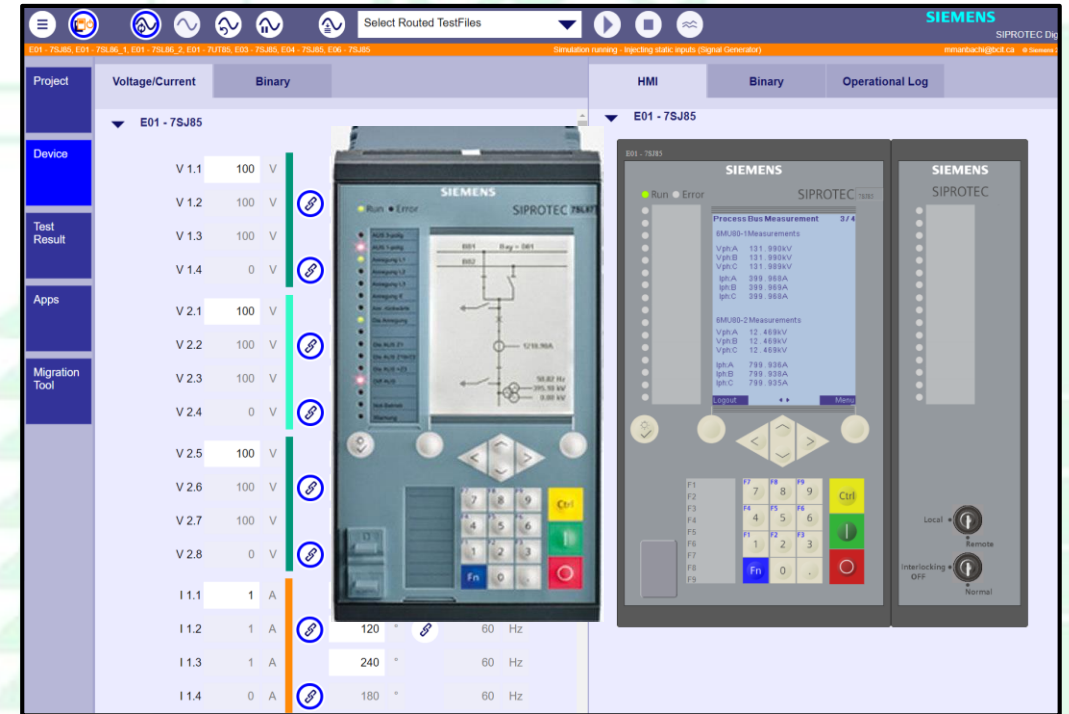


Communication to Cloud:



SIPROTEC Digital Twins:

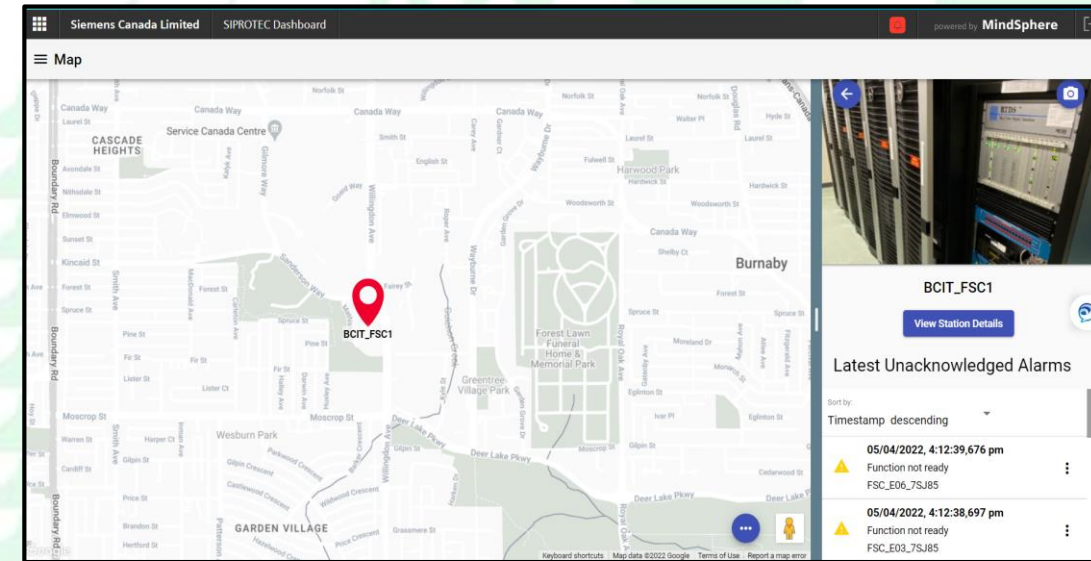
- Front display visualization and operation
- Injection of V/Is, binary inputs, etc.
- Substation integration tests
- Fault analysis (e.g., replay of records)
- Test cybersecurity functions
- Test of protection functions & automation logics
- IEC 61850 Goose communication between devices, (e.g., interlockings)



Cloud-based Applications:



SIPROTEC Dashboard

- Monitor the operational status of devices
- Data transparency in grid operation using cloud
- Optimizing substation maintenance activities
- Status of field IEDs
- Critical deviations from normal operation (e.g., protection trips/pickups and IEDs in unhealthy states)




Cloud-based Applications (cont.):

SIPROTEC Dashboard (cont.)


 Siemens Canada Limited SIPROTEC Dashboard  powered by **MindSphere**

Map ▶ BCIT_FSC1 ▶ Devices


FSC_E01_7SJ85
SIPROTEC 7SJ85
Overcurrent and feeder protection



FSC_E01_7UT85
SIPROTEC 7UT85
Transformer differential protection



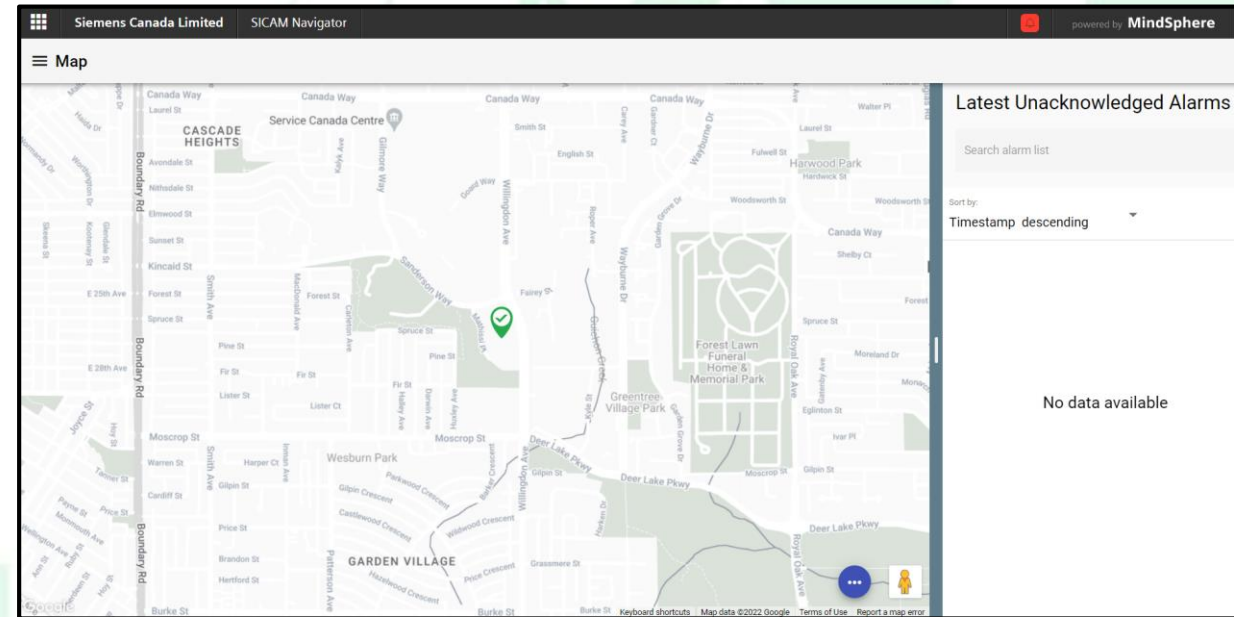
FSC_E03_7SJ85
SIPROTEC 7SJ85
Overcurrent and feeder protection

**FSC_E06_7SJ85**
SIPROTEC 7SJ85
Overcurrent and feeder protection**FSC_E01_7SL86_1**
SIPROTEC 7SL86
Line differential and distance protection**FSC_E01_7SL86_2**
SIPROTEC 7SL86
Line differential and distance protection**FSC_E04_7SJ85**
SIPROTEC 7SJ85
Overcurrent and feeder protection

Cloud-based Applications (cont.):

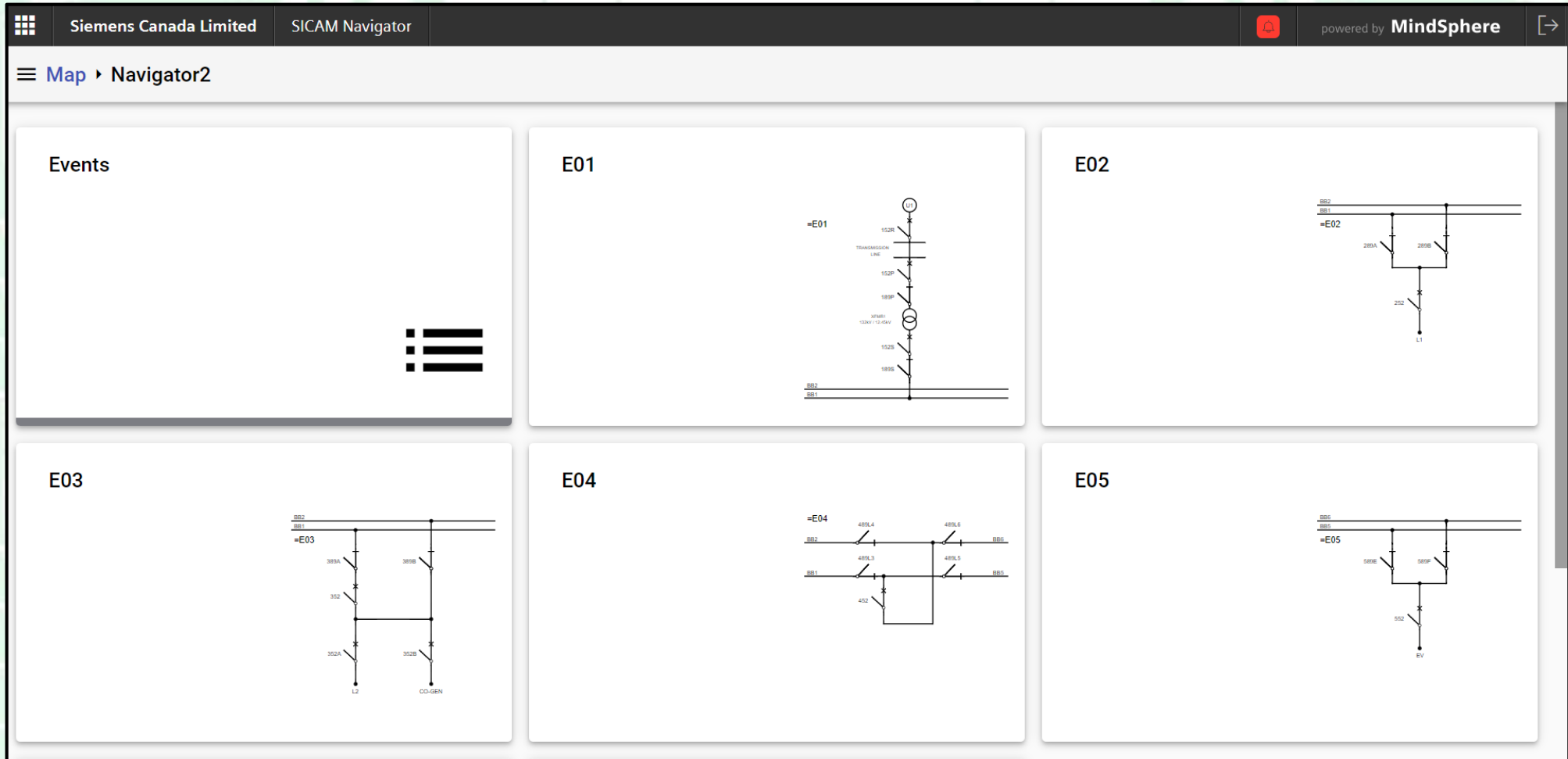
SICAM Navigator

- Monitor grid and assets
- Fault location
- Support root cause analysis
- Optimized maintenance activities
- Data from an entire grid and/or substations could be available on the cloud: without additional engineering effort or configuration



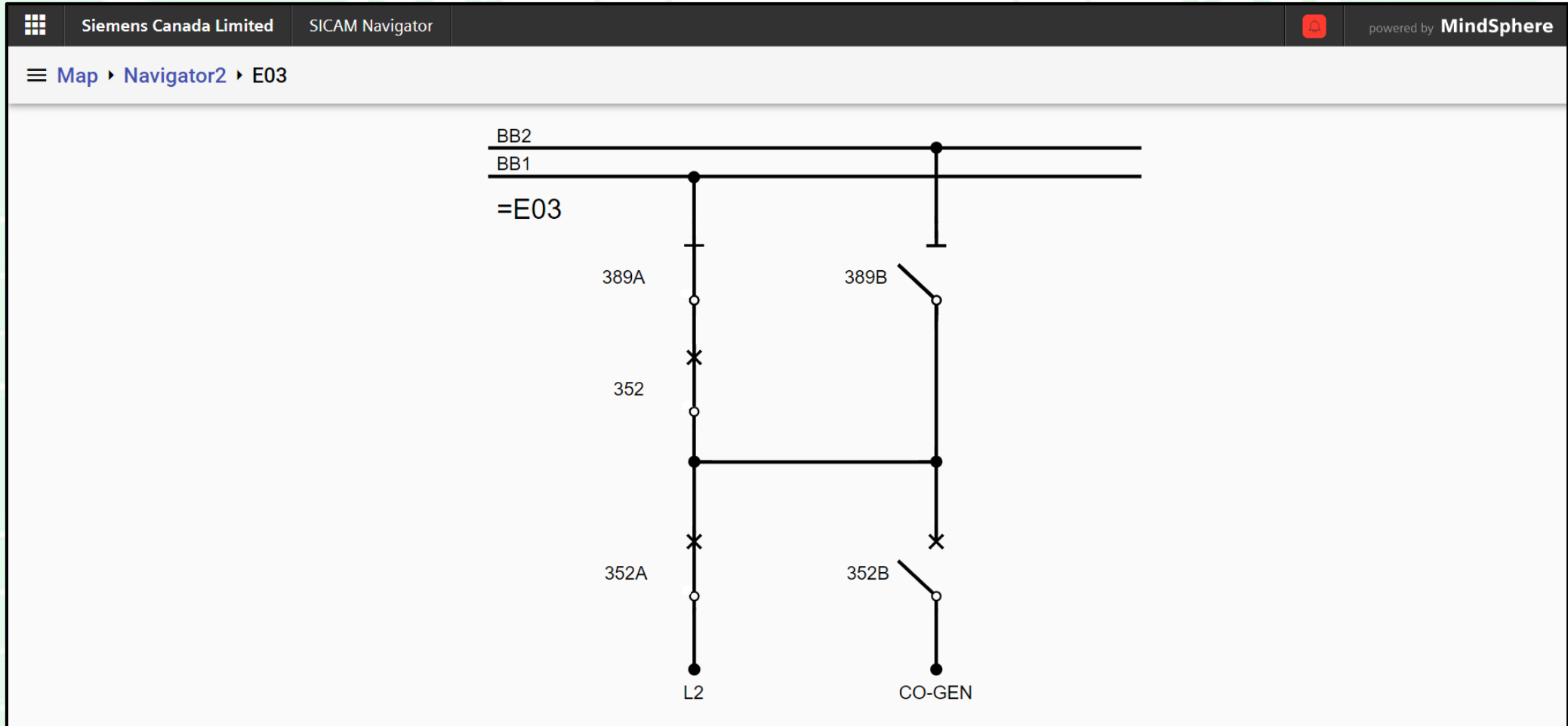
Cloud-based Applications (cont.):

SICAM Navigator (cont.)

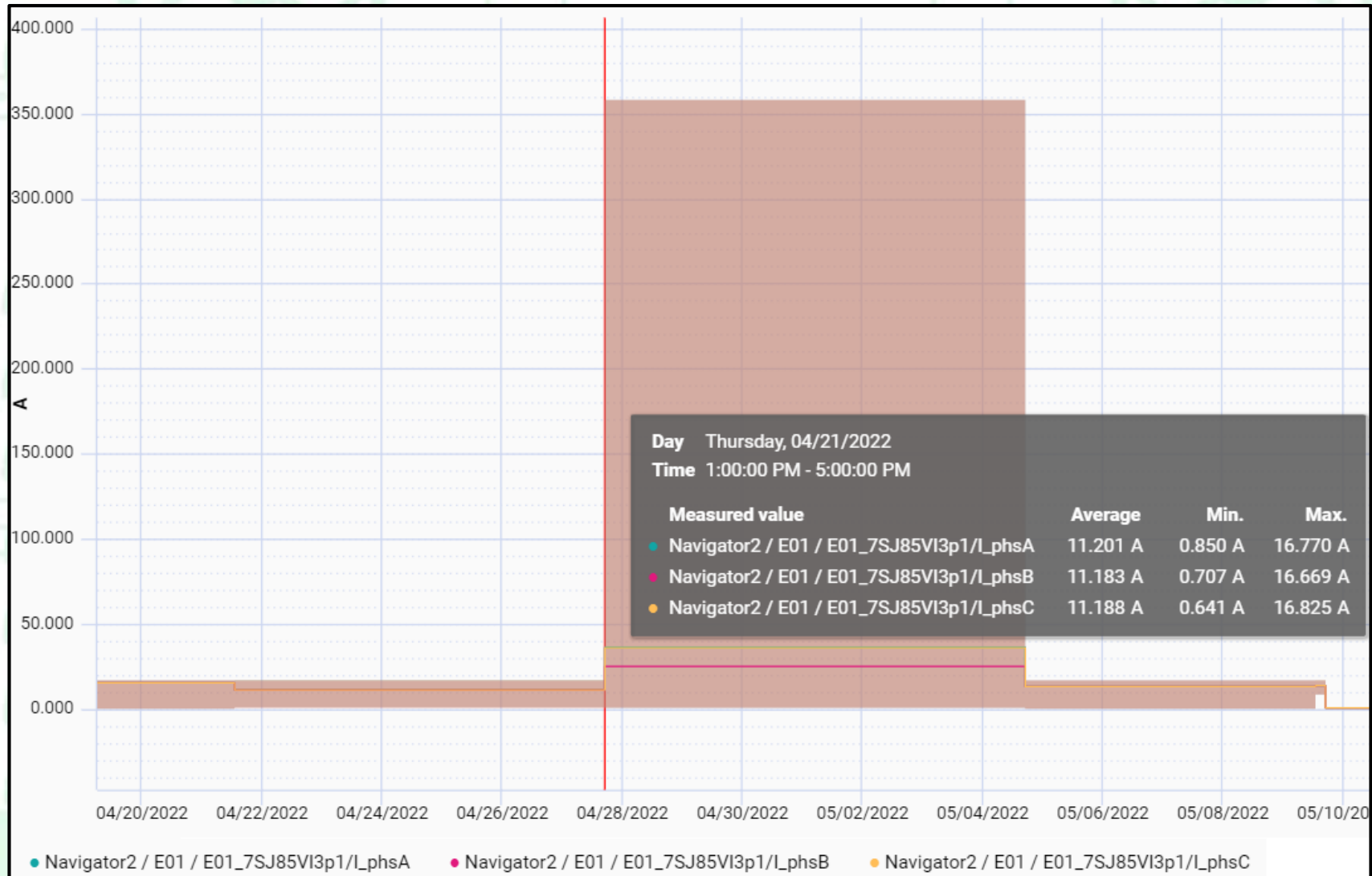


Cloud-based Applications (cont.):

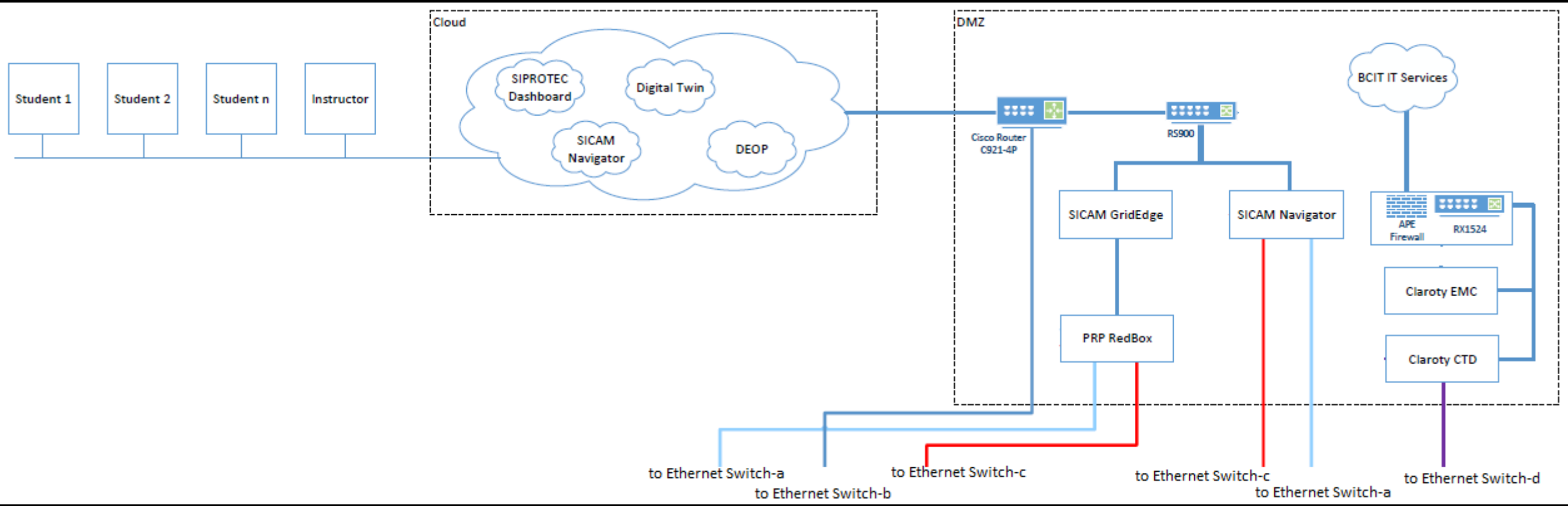
SICAM Navigator (cont.)



SICAM Navigator (cont.)



Cybersecurity Architecture:



Conclusions:

Virtualized learning platform for vocational training

Virtualization technologies: digital twins and cloud-based apps

The body of knowledge created could be used in other domains

Virtualization Steps

Platform Communication and Cybersecurity Architectures

Upcoming Works:

Virtualization of other critical energy infrastructures using open source platforms

Pilot Sessions:

- Study proper pedagogical models for remote experiential learning using the platform
- Investigate how experiential learning through such platforms can be measured and assessed

Would you like to work with BCIT's Virtualized Experiential Learning Platform?

Please Contact: Dr. Moein Manbachi
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Thank You!
Questions?

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